Management and Evaluation of Non-supervised Home Exercise Program in a Convalescent Phase of Acute Myocardial Infarction

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Out of 636 patients with acute myocardial infarction (AMI) admitted to our institution, 183 patients enrolled in our non-supervised home exercise program immediately after their discharge from the hospital. The first 40 patients were randomized to control and training group, while the remaining 143 patients were included in the training group. Before and after the trial, all patients underwent cardiopulmonary exercise testing; submaximal graded treadmill exercise test with the application of expiratory gas analysis.

In the training group, patients performed 2 km walk-jog exercise everyday for 1 month, keeping their heart rate (HR) at 90–100% of that in the anaerobic threshold. HR during exercise was monitored by patients themselves, using HR-meter. The anaerobic threshold significantly increased in the training group; while control group had no significant changes. $\dot{V}O_2$ and HR significantly increased at the same Borg's indices. Psychological improvement was also obtained in the training group compared to control group. It is concluded that non-supervised home exercise program is effective and easily applicable in the convalescent phase of AMI.

ALTHOUGH the demand for cardiac rehabilitation has increased recently in Japan, such programs have not been developed in Japan as they have been in the United States and European countries. There are several reasons for this: patients with myocardial infarction still have long hospitalization but they have complete health insurance coverage and guarantee of employment after recovery. The incidence of ischemic heart disease is also far lower than that of the Western countries! Our National Cardiovascular Center is one of the largest specialized hospitals cardiovascular

disease in Japan. Approximately 600 patients with coronary artery disease, as well as 400 post-operative patients are newly registered every year as candidates for cardiac rehabilitation. However, we have no cardiac rehabilitation facilities in our hospital. So we developed a "non-supervised home exercise program" 5 year ago patients in the convalescent phase. This paper reports on: 1) the cardiopulmonary exercise testing² and exercise prescription, 2) non-supervised home exercise program, and 3) the efficacy of home exercise program.

Key words:

Acute myocardial infarction
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SUBJECTS AND METHODS

1. Subjects

Entry criteria for our exercise program are as follows; 1) age less than 70 year old for

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TABLE I BORG'S INDICES. THE ORIGINAL RATING OF PERCEIVED EXERTION SCALE

Score	Symptom	Intensity (%)
20		100
19	very, very hard	93
18		86
17	very hard	79
16		72
15	hard	64
14		57
13	somewhat hard	50
12		43
11	fairly light	36
10		29
9	very light	21
8		14
7	very, very light	7
6	(resting)	0

males, 65 years for females, 2) a willingness to be rehabilitated, and 3) no contraindications for exercise program (e.g., poor left ventricular function, severe angina pectoris, serious ventricular arrhythmia, and gait disturbance).

Among 636 patients with acute myocardial infarction (AMI) admitted to our CCU from Nov. 1984 to Sep. 1988, 183 patients entered this program. One hundred and sixty-four patients were males and 19 were females, with mean age of 55.3 years. The first 40 patients were randomized to control and training group, and the remaining 143 patients were allocated to the training group.

2. Exercise Test

After patient selection, cardiopulmonary exercise testing was performed in order to obtain the exercise prescription. Cardiopulmonary exercise testing involved a submaximal graded treadmill exercise test with expiratory gas analysis, subjective symptomatic evaluation of dyspnea and leg fatigue using Borg's indices³ (Table I) and blood lactate sampling for selected patients. Treadmill test was performed using the Marquette CASE 12 with 2 min incremental protocol (Table II) and the SensorMedics MMC Horizon system for expiratory gas analysis. The blood lactate was measured by Yellow Spring Instrument Lactate Analyzer 23L. Before cardiopulmonary exercise testing, the patient was instructed to rate the degree of

TABLE II TREADMILL PROTOCOL IN CARDIOPULMONARY EXERCISE TESTING

Stage	Speed (km/h)	Grade (%)	Duration (min)
0	2.5	0	2
1	2.5	10	2
2	3.5	10	2
3	4.5	10	2
4	5.5	10	2
5	5.5	14	2
6	5.5	18	2
7	5.5	22	2
8	6.5	22	2

dyspnea and leg fatigue using Borg's indices as accurately and naively as possible. The indices presented in quatro format were shown to the patient, and the patient had to point with his finger at the suitable index value. Peak $\dot{V}O_2$ and anaerobic threshold were determined from cardiopulmonary exercise testing⁴.

The exercise end points were dyspnea or leg fatigue, of more than 17 as evaluated by Borg's indices, ischemic findings, and the target heart rate set at 70–80% of the predicted maximal heart rate.

3. Non-Supervised Home Exercise Program

If the patient completes the test without severe subjective symptoms or significant ST changes and other ischemic findings, the exercise prescription is given as follows. The heart rate at the work load of anaerobic threshold was determined by cardiopulmonary exercise testing. Our program consists of a 2 km (1 km in the 1 week of discharge) walk-jog, once a day, every day for 1 month, with heart rate keeping at 90–100% of the heart rate at the anaerobic threshold during exercise, monitored by using a heart rate-meter. We also provided the patient manpo-kei for counting walking steps, and total steps of a day were measured and recorded by the patient.

We gave a guide book for exercise program to each patient who entered this program. The patient recorded total daily steps, walking time and distance, heart rate before and during exercise, and subjective symptoms in the exercise page of the diary in this guide book. Most patients were very diligent in keeping this record.

Fig.1. Training effects in physical situation.

After the one month on the exercise program, the same cardiopulmonary exercise testing was performed to evaluate the effect of our program. We also sent out questionnaires to investigate the psychosocial effects of our exercise program.

We discharged control group under usual guidance without providing the exercise prescription, but the same exercise tests were performed before and one month after discharge.

RESULTS

Figure 1 shows the changes in various parameters in control group and training group. Anaerobic threshold significantly increased in the training group, while control group had no significant changes. Resting blood pressure increased significantly in control groups, while no significant change occurred in the training group.

Heart rate at the same submaximal work load significantly decreased in both group,

and there were no significant differences between these two groups. Peak $\dot{V}O_2$ and oxygen pulse at the same submaximal work load increased in the training group only, but there were no statistical differences between these two groups. $\dot{V}O_2$ at the same submaximal work load did not significantly change in either group.

Figures 2 shows the correlation between Borg's indices of dyspnea and the parameters such as $\dot{V}O_2$, $\dot{V}E$, heart rate, and blood lactate, before and after our exercise program. $\dot{V}O_2$ and heart rate increase linearly with Borg's indices, while $\dot{V}E$ and lactate have disproportionate increases after Borg's 13 ("somewhat hard").

After one month of physical training, $\dot{V}O_2$ and heart rate significantly increased at the same Borg's indices. But there was no significant changes in blood lactate at the same Borg's score before and after training. The similar relationship was also found in Borg's indices of leg fatigue and related parameters.

As to the psychological effects of the prog-

Fig.2. Correlation between Borg's indices (dyspnea) and the parameters in cardiopulmonary exercise testing.

Fig.3. Training effects in psychological situation.

ram, those in the training group had marked improvement compared to control group, as shown by an increase in the number of patients who expressed a feeling of health after discharge. There is also a decreased tendency in subjective symptoms such as exertional dyspnea or palpitation (Fig. 3).

DISCUSSION

Physical training has the potential to exert certain favorable effects on patients with myocardial infarction. Physical training of patients who are recovering from an uncomplicated myocardial infarction has been almost uniformly observed to produce an increase in symptom-limited $\dot{V}O_2$.⁵ However, in Japan, outpatient exercise programs have not been well established because of the lack of facilities and programs. Therefore, we developed a non-supervised home exercise program and applied it to patients with AMI after their discharge from the hospital.

Among 636 patients with AMI admitted to CCU, 183 patients enrolled in this program.

Two thirds of the patients were excluded from the program because of advanced age, severe angina, poor left ventricular function and gait disturbance.

After patient selection, cardiopulmonary exercise testing was done in order to determine exercise prescription. Our treadmill protocol in cardiopulmonary exercise testing was specially designed by our hospital⁶. We believe that the initial work rate of the Bruce's or the Ellestad's protocols are quite high and are inappropriate for the relatively smaller Japanese patients with AMI. We therefore used a lower initial and incremental work rate in our protocol so patients could attain their anaerobic threshold and peak $\dot{V}O_2$ within 20 min. We could easily determine anaerobic threshold by using MMC Horizon system with special treadmill protocol for about 93% of the patients entered in this program⁴.

The training effects are best expressed by a change in maximal oxygen uptake. However, we did not employ maximal exercise test in this study. Instead, such parameters as anaerobic threshold, peak $\dot{V}O_2$, resting blood pressure, heart rate, $\dot{V}O_2$ and oxygen pulse at the same submaximal work load and Borg's indices were used to evaluate our program.

The intensity of exercise in the recommended exercise prescription by the American College of Sports Medicine is 55–85% of maximal $\dot{V}O_2$ and 60–90% of maximal heart rate⁷. This exercise prescription, however, is not appropriate because of our submaximal exercise test. In our prescription, the intensity is determined only by heart rate — 90–100% of the heart rate at anaerobic threshold-during exercise. As we reported before⁸, we first prescribed the work intensity of heart rate of 100–110/min uniformly, but the individual work load of this heart rate varied widely from approximately 3 METS in the most poorly conditioned patient to about 6 METS in the most-fit patient. Changes in anaerobic threshold before and after training inversely correlated with pre-training anaerobic threshold. Uniformly prescribed exercise program was effective on its own, but not so effective in those with already good exercise capacity. When the heart rate of 100–110/min was represented with the percentage of heart rate at anaero-

bic threshold, those whose exercise capacity improved well had 80–100% of heart rate at anaerobic threshold⁹. We found exercise prescription based on the heart rate at anaerobic threshold is very effective and thereafter we prescribed the intensity of exercise by 90–100% of heart rate at anaerobic threshold individually from cardiopulmonary exercise testing.

Changes in anaerobic threshold was significant between the training and control group, but there was no significant change in the control group. In other parameters, except resting blood pressure, there were no statistical differences between these two groups. The reason we could not attain the statistical difference between the training and control group, may be due to the fact that those in the control group exercised on their own. In fact, the average total steps of a day were almost the same in the two groups.

Although American College of Sports Medicine recommended the exercise duration of 30–60 min and the frequency of 3–4 times per week, our exercise prescription was about 30 min of duration, everyday for 1 month. One month may be somewhat short, however most patients went back to work 1 month after discharge from the hospital. And within the period of 1 month, there is good compliance with an exercise prescription. Ninety-three per cent of the patients kept their exercise program.

The Borg's indices, the rate of perceived exertion, have been widely accepted for evaluating subjective symptoms semi-quantitatively in exercise tests. The values of this scale grow fairly linear with the work load and heart rate. As a rough approximation the heart rate for middle aged people should, for work loads of medium intensity levels, be fairly close to ten times the Borg's indices. As we reported before¹⁰, the reproducibility of Borg's indices were fairly good. In the cardiopulmonary exercise testing, performed before and after the program, $\dot{V}O_2$ and heart rate increased linearly with Borg's indices, however VE and blood lactate had disproportionate increases after the Borg's 13. These results indicate that the Borg's 13 coincide with the anaerobic threshold. In fact, by individual measurement of blood lactate and expiratory gas analysis, anaerobic

threshold appeared at the Borg's 13 in almost 60% of the patients!¹⁰

After one month physical training $\dot{V}O_2$ and heart rate were significantly increased at the same Borg's indices, but there were no significant changes in blood lactate at the same Borg's score before and after the training, suggesting that, in patients with AMI, exercise capacity significantly increased at any score of subjective symptoms. Borg's indices, which closely relate to the lactate dynamics, are not only useful in quantifying subjective symptoms but also in estimating the efficacy of physical training!¹¹

Finally, we investigated the psychological effects of our exercise program. We found psychological improvement in the training group, as shown by a increase in the number of patients who had recovery of feeling of health. There is also a decreased tendency in subjective symptoms such as exertional dyspnea or palpitation. Many investigators reported the effects of various types of cardiac rehabilitation on psychological states. Morgan,¹² for example, noted that a program of physical exercise led to a significant reduction in self-reported anxiety and to a somewhat lesser decrease in depression. Exercise training also appeared to increase self-esteem and unprove perception of one's health status, thus providing reinforcement and increased motivation for further adherence to the rehabilitative regimen. Exercise training provides these patients with "something to do" in a medical situation where the list of prohibited activities is quite long, and in this way elevate their self-esteem in a positive way!¹³

The merits of our non-supervised home exercise program can be summarized as follows: 1) few requirements for special equipment and facilities, 2) good compliance for exercise prescription, probably due to the shortness of the program, 3) good efficacy not only in physical aspect but also in psychological aspect. Our non-supervised home exercise program in a convalescent phase of AMI is inexpensive and effective for cardiac rehabilitation.

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